# CONSEQUENCES OF NOT MAINTAINING ADEQUATE RAIL NEUTRAL TEMPERATURE

FRA Track Safety Symposium
St. Louis, MO
April 5, 2022

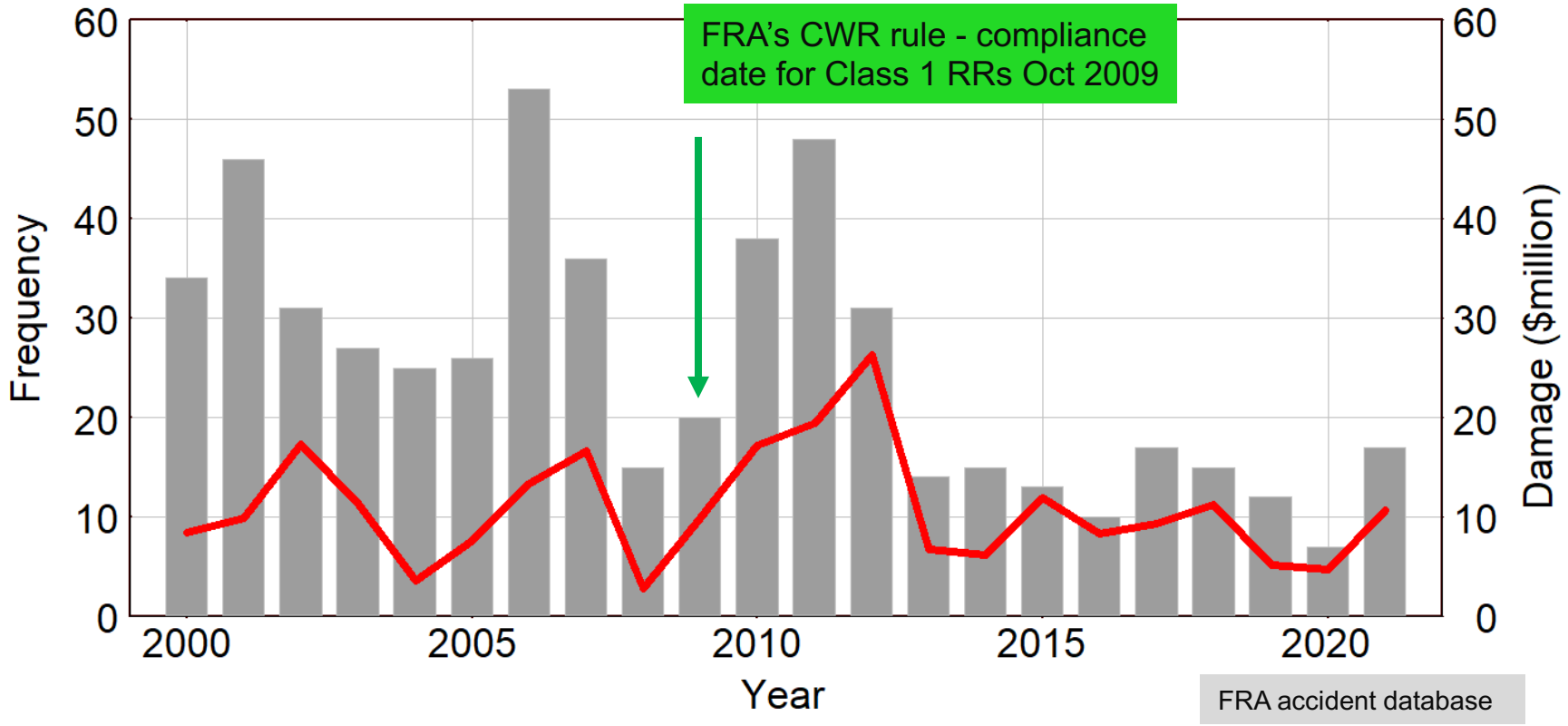
*Brad Kerchof*
*Advanced Rail Management*
*Norfolk Southern Railway (retired)*

# KEY CONCEPTS

| | |
|---|---|
| T109 | FRA cause code for track alignment irregular (buckled/sunkink) |
| RNT | Rail Neutral Temperature |
| ΔT | Change in temperature; also difference between RNT and actual rail temperature |
| ΔT of 60°F | Threshold for wood tie track buckling |
| Typical rail temp range | -20° to 135°F (ambient -20° to 100°F) |
| Solar Absorption | The increase in rail temperature above ambient caused by solar radiation |

Internet search "buckled track photos"

# T109 TRACK ALIGNMENT IRREGULAR (BUCKLED/SUNKINK)

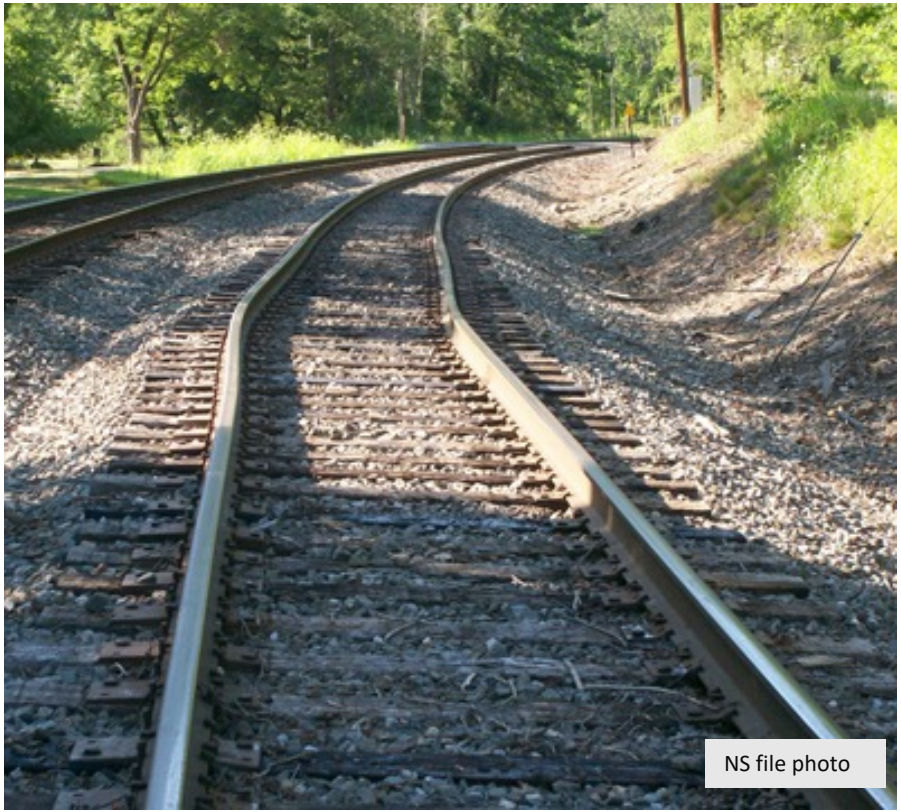


# WHAT IS RAIL NEUTRAL TEMPERATURE (RNT)?

- Temperature at which rail is neither in compression nor tension
- Temperature at which rail is (longitudinally) stress-free
- Temperature at which rail is installed

# WHY IS RNT IMPORTANT?

Knowing RNT allows us to manage the risk of buckled track



# RELATIONSHIP BETWEEN RAIL LENGTH AND TEMPERATURE

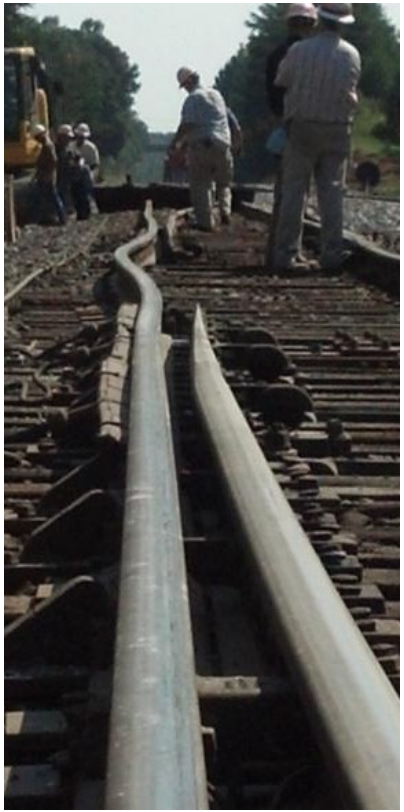
$$\delta_T = a \bullet \Delta T \bullet L$$

Where

- $\delta_T$ – change in length due to change in temperature (inches)
- a - coefficient of thermal expansion for steel ($6.6 \times 10^{-6}$ in/in/°F)
- $\Delta T$ - change in temperature (°F)
- L - initial length (inches)

For a 100-ft piece of rail, $\Delta T$ of 60°F results in $\delta_T = 0.5$ inches

For 1440 ft of welded rail, $\Delta T$ of 60°F results in $\delta_T = 6.6$ inches



# WHAT IS A REASONABLE RNT?

One railroad's standard procedure:

- ✓ Install at 95°F (40° below likely max rail temp)
- ✓ Use a rail heater if temperature is less than 80°

# WHAT CAUSES TRACK TO BUCKLE?

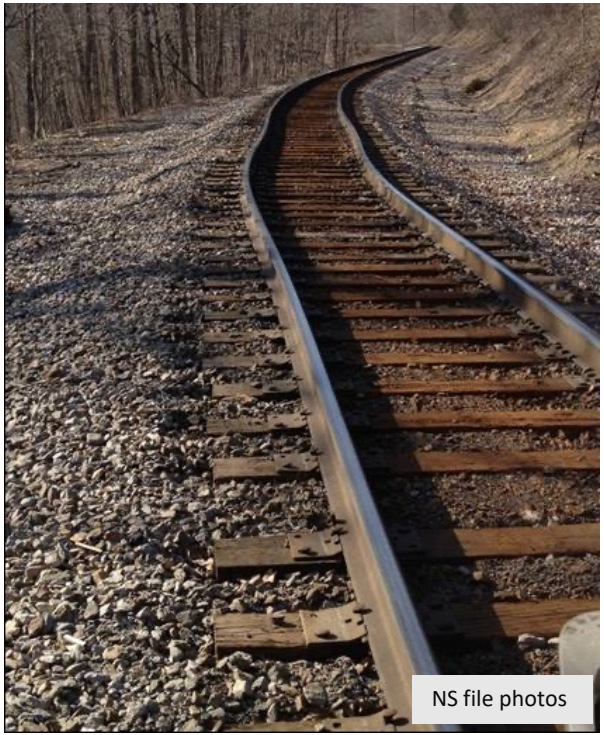
A large ΔT (a large difference between RNT and actual rail temp); on wood tie track, at least 60$^{o}$.

Typically…the root cause of a track buckle is not that the actual rail temp has gotten too high…. It's that RNT has gotten too low.

Internet search "buckled track photos"

# WHAT CAN CAUSE LOW RNT?

Repairing this broken weld will add close to 3 inches of rail (rail temp at the time was 20˚F)




This curve pulled inward in cold weather (note voids at the ends of the ties)

# WHAT CAN CAUSE LOW RNT?

1) Laying rail at too low a temperature
2) Adding rail by cutting in a longer piece than is cut out
3) Adding rail by making thermit welds when joints are pulled open
4) A curve pulls inward during cold weather, shortening its length
5) Insufficient rail restraint – rail moves longitudinally under train traffic (due to insufficient or ineffective anchors), causing an increase in RNT at one spot and a decrease in RNT at another spot
6) Heat transfer from wheels, caused by a train traveling down grade with air brakes applied (this does not change RNT; rather, it can cause an unusually high actual temp)

NS file photo

# CONSEQUENCES OF LOW RNT

**Next up: Four buckled track derailments caused by low RNT due to…..**

- Adding rail by cutting in a longer piece than was cut out (during cold weather)
- Adding rail by making thermit welds when joints are pulled apart (during cold weather)

NTSB Railroad Accident Brief, no. DCA-06-FR-006

# CONSEQUENCE OF LOW RNT (#1)

Mt. Airy, GA - August 2012

- Preceding November – Installed 4 stock rails, 4 switch points & both rails between switches, rail temp 60°.
- January – A dozen thermite welds at temps between 14° and 53°; 2 inches added to each side, according to welders' rail-added reports.
- August 1 - Buckled track derailment, air temp 91°

Rail temp analysis

- RNT est. 20° - 50°, actual rail temp 110°, $\Delta T > 60°$


NS file photo

# CONSEQUENCE OF LOW RNT (#2)

Bowler, VA - May 2012

- February – Removed a no. 20 turnout, installed a no. 10 turnout and 3 track panels. Temperature was in the upper 40's. No rail-added report.
- March – 18 thermite welds at temps between 50˚ and 60˚. No rail-added report.
- May 16 – Buckled track derailment, air temp 83°

Rail temp analysis

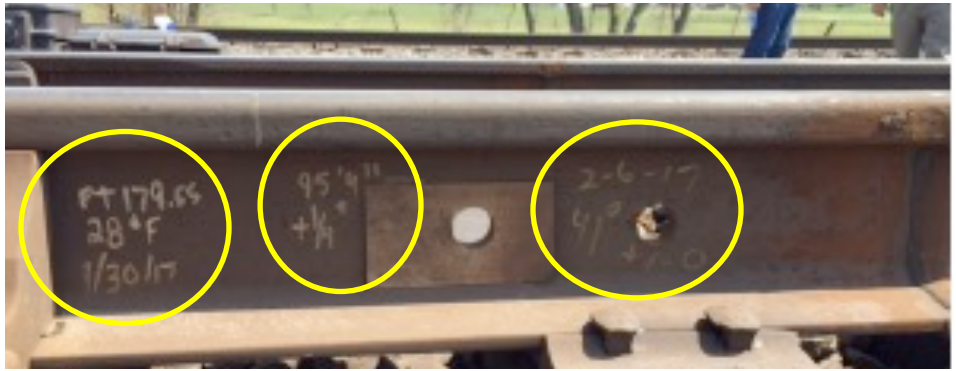
- RNT est. 50°, actual rail temp 110°, ΔT 60°

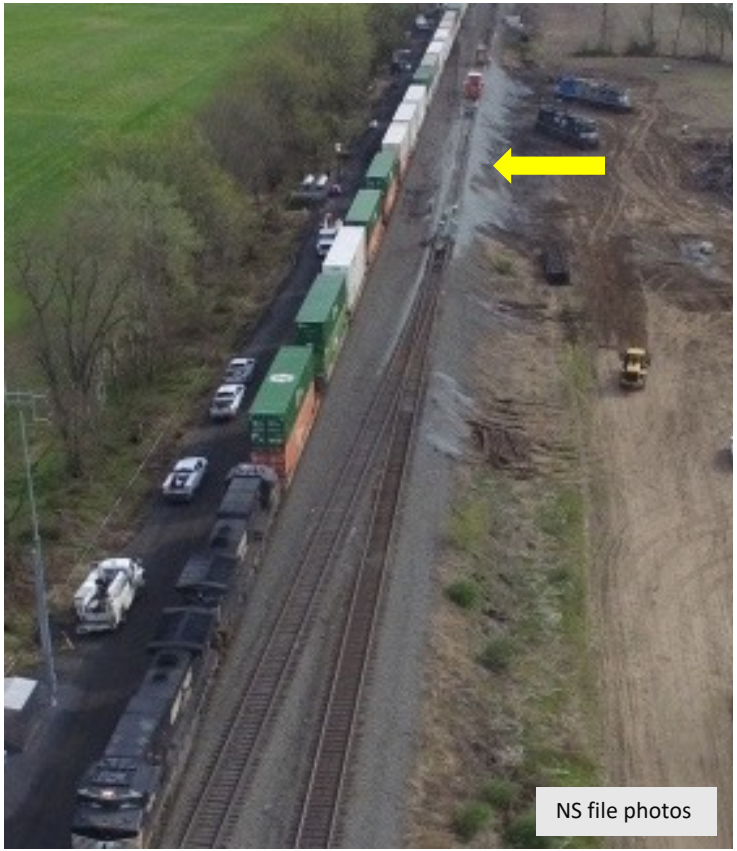
# CONSEQUENCE OF LOW RNT (#3)

McVey, PA - April 2017

- January - Installed two 95-ft rails between two no. 20 turnouts, temp 28˚ N rail and 44° S rail; rail added 1/4” and 1/8”.
- February – 6 thermite welds at 41˚; 0” rail added.
- April 14 forecast – high temperature of 69°

Feeling any anxiety?



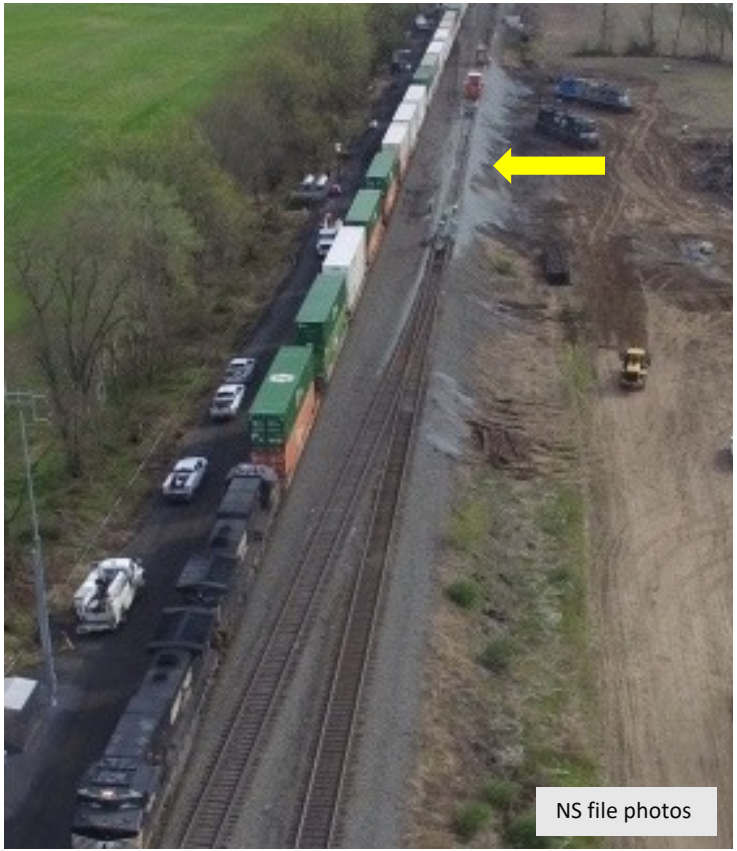
# CONSEQUENCE OF LOW RNT (#3)

McVey, PA - April 2017

- January - Installed two 95-ft rails between two no. 20 turnouts, temps 28˚ N rail and 44° S rail
- February - Thermite welds at 41˚
- April 14 – Buckled track derailment, air temp 69°

Rail temp analysis

- RNT 28° - 44°, actual rail temp est. 95° by ENSCO rail prediction model, ΔT 60°



# CONSEQUENCE OF LOW RNT (#4)

Rural Retreat, VA - April 2019

- Preceding November - Installed 42 ft. rails on H and L sides through crossing; joints thermite welded; temp < 30$^{o}$ for all of this work.
- January – Changed out Sperry rail adjacent to crossing on H rail; joints thermite welded; temp < 30$^{o}$.
- Crossing was on the supervisor's rail-added list; adjustment waiting for warm weather.
- April 6 forecast: temperature in the mid 60's

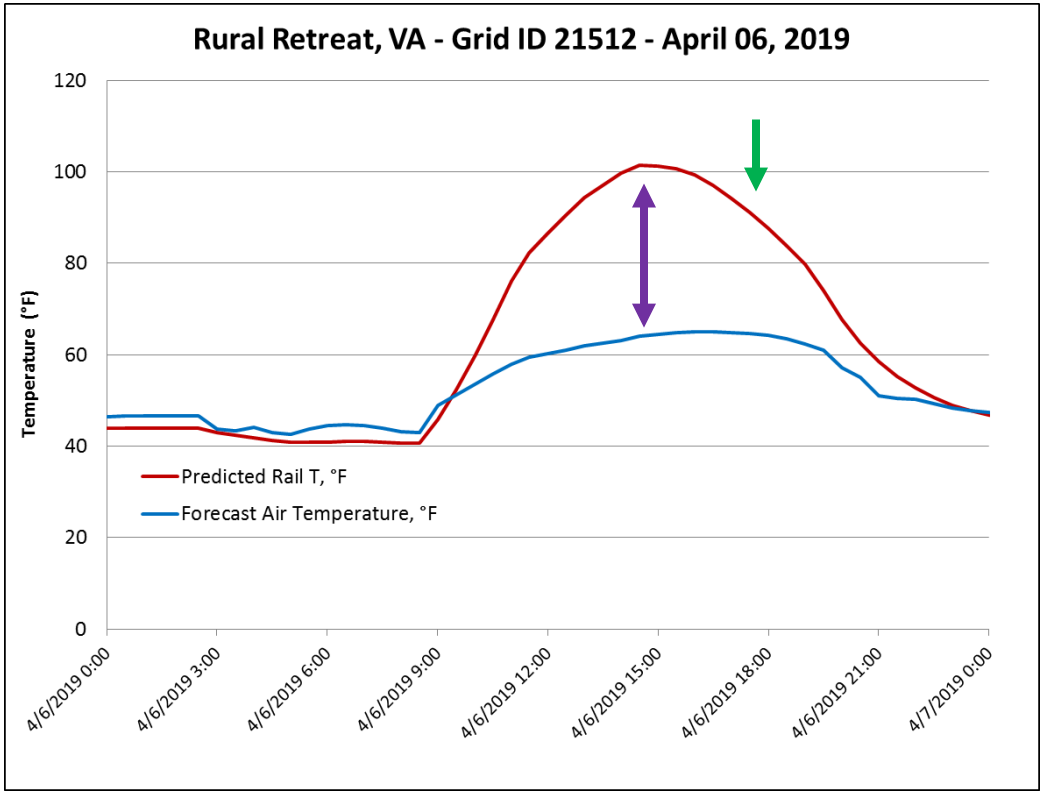
Feeling any anxiety?

# RAIL ADDED DATA WAS RECORDED PROPERLY (#4)

| RIGHT RAIL | | | | | |
|---|---|---|---|---|---|
| Date | Rail Added | MP | | Work | Temp |
| 11/14/2018 | 1 | NB | 348.95 | Rail change-out thru xing | 27 |
| 11/27/2018 | 0.5 | NB | 348.95 | Thermite Weld | 29 |
| 11/28/2018 | 0.5 | NB | 348.96 | Thermite Weld | 25 |
| 1/31/2019 | 0.5 | NB | 348.97 | Sperry Defect | 18 |
| TOTAL | 2.5 | | | | |

| LEFT RAIL | | | | | |
|---|---|---|---|---|---|
| Date | Rail Added | MP | | Work | Temp |
| 11/14/2018 | 1 | NB | 348.95 | Rail change-out thru xing | 27 |
| 11/28/2018 | 0.75 | NB | 348.95 | Thermite Weld | 24 |
| TOTAL | 1.75 | | | | |

# ENSCO RAIL TEMPERATURE PREDICTION MODEL (#4)




- The accuracy of the model was validated when we measured actual rail temp of 88° at 6:00 pm
- Note difference between ambient (64°) and predicted rail temp (101°) at 3:00 pm (time of derailment)
- The impact of solar radiation was substantial – predicted rail temp was 37° above ambient

Rail temp analysis

- RNT < 30°, actual rail temp est. 101° by ENSCO model, $\Delta T > 60^{o}$

# OBSERVATIONS FROM THESE FOUR DERAILMENTS

1st & 2nd derailments

- 150+ ft of rail changed out and welds made at temperatures between 40° & 50°
- Rail added recorded at only one of site
- Neither site was “on the list” for adjustment. Air temps at time of derailment were 83° and 91°

3rd & 4th derailments

- 40 - 95 ft of rail changed out and welds made at temperatures between 18° an 44°
- Track folks did an excellent job documenting rail added
- Both sites were “on the list” for adjustment
- Track buckled at a surprisingly low air temperature – in the 60’s!

# WHAT TO TAKE AWAY FROM THIS PRESENTATION

1) Most buckled track derailments are related to something that happened during cold weather (track shift, rail change-out or welding) that resulted in a lower RNT.

2) How you handle these cold-weather changes to RNT is key to managing your risk of buckled track.

3) Keep a record of any trackwork (or curve shifts) that results in a lower RNT. Then adjust that rail at your first opportunity come warm weather.

4) Track buckling is determined by $\Delta T$, not ambient temperature.

5) FRA data shows that the majority of buckled track derailments occur near fixed assets – a turnout, road crossing or bridge. My suspicion: Rail change-outs (and welding) are likely to occur at these locations.

# QUESTIONS?

This misalignment is not a heat buckle – its shape is not the typical “S” found in tangent track (like the heat kink above).

Rather, this misalignment was caused by a severe train run-in, which pushed two-car lengths of track to one side.